ORIGINAL RESEARCH

THE EFFECTS OF TWO ADHESIVE ANKLE-TAPING METHODS ON STRENGTH, POWER, AND RANGE OF MOTION IN FEMALE ATHLETES

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ABSTRACT

Background. Taping is a ubiquitous strategy to help prevent ankle sprains. The restrictive qualities of various taping methods may impair athletic performance.

Objective. The objective of the study was to compare the Gibney closed basket weave taping method with heel-locks to heel-locks and figure-eights in order to determine their effect on vertical jump performance and active range of motion (ROM) before and after exercise.

Methods. Eleven female varsity basketball athletes were subjected to three conditions of no ankle support (control), heel-locks, and figure-eights. The dependent variables of ankle active ROM, plantarflexor maximum voluntary contraction and jump height for the countermovement jump (CMJ), drop jump (DJ), and concentric only squat jump (COSJ) were randomly ordered. Following taping or control conditions, participants were pre-tested, completed a ten-minute treadmill run at 9.6 km/hr with a 3 minute cool down and then repeated the testing procedures.

Results. There were no significant differences in jump performance between taping methods or the effect of exercise. However significant differences for pre-/post-exercise for plantarflexor ($p < 0.0001$) and dorsiflexor ($p = 0.007$) active ROM and between no support and taping for plantarflexor ROM ($p = 0.004$) was found.

Conclusions: Despite plantarflexor active ROM being restricted by both taping procedures compared to the control, no effect on jump performance occurred.

Key words: flexibility, drop jump, countermovement jump, squat jump, ankle sprain

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INTRODUCTION

Ankle sprains are the most common musculoskeletal injury found among all athletes regardless of age or level of participation.[1] As a result of the high incidence of these injuries, medical personnel, coaches, and athletes are eager to find the optimal ankle stabilizer that will help to reduce injuries while minimizing the effect it may have on performance. Research has shown that the mechanical stability and increased proprioception external supports create on the ankle joint work to help prevent ankle injury during physical activity.[2-6] If, however, the restrictive qualities of these supports were detrimental to athletic performance, then athletes, coaches and athletic trainers would be deterred from using the supports despite these preventive measures.

The types of ankle stabilizers commonly used are adhesive tape and ankle braces with the main goal of both being to support the unstable ankle from injury without having an effect on athletic performance.[7] Many sports medicine personnel and athletes prefer taping over bracing due to increased comfort, increased support and decreased interference with normal ankle function.[6] The most prevalent taping method utilized today is the Gibney closed basketweave in conjunction with the heel-lock or the figure-eight.[5,7-10]

With the application of adhesive tape being highly utilized for supporting the ankle joint during exercise and with more than one taping method available, it is important to determine and understand the differences, if any, between the methods used. However, the majority of the research in this area has dealt with comparisons between taping and bracing on athletic performance.[11-14] Different performance parameters have been tested with inconclusive results found in relation to ankle supports and vertical jump height. Some studies have found a significant reduction in vertical jump height as a result of the application of an external support,[1,8,10] while others found no significant effect on vertical jump height with the application of tape or a brace when compared to no support.[7,10,11,15] Therefore, the purpose of this study was to compare the effect of the Gibney closed basketweave taping method with heel locks to the Gibney closed basketweave with heel-locks and figure-eights on vertical jump performance.

METHODS

Experimental Design

Participants were tested before and after the application of a Gibney closed basketweave with heel locks (HL), Gibney closed basketweave with heel locks and figure - eights, and a control condition. Following the application of the tape, participants ran on a treadmill for 10 min at 9.6 km.h-1 with a level grade and then were re-tested with the same cadre of tests used in the pre-test. These measures consisted of ankle active range of motion (ROM); drop, countermovement, and concentric only squat jumps; and plantarflexor maximal voluntary contraction.

Subjects

Eleven female college basketball athletes (height = 172.1 $\pm$ 6.7cm, weight = 69.2 $\pm$ 12.9kg, age = 20.6 $\pm$ 1.4, range, 19 to 25 years) with no ankle injury in the past three months volunteered to participate in this study. The attending athletic therapist assessed all subjects for healthy ankle function. Approval from the Interdisciplinary Committee in Ethics in Human Research (ICEHR) at Memorial University of Newfoundland was obtained and written informed consent was obtained from all subjects.

Instruments

All vertical jumps were performed using a contact mat (Innervations, Muncie, IN) and analyzed using the Kinematics Measurement Systems (Innervations, Muncie, IN) software program.[16,22,26] The software program recorded jump height based on flight time. In order to ensure validity of the test, participants were asked to have their knees as fully extended as possible and ankles completely plantarflexed at both take off and landing.[16]

Subjects performed plantarflexor maximal voluntary control while seated in a straight-backed chair with hips and knees at 90°. Isometric contractions were performed with their leg secured in a modified boot apparatus[16] with their ankles flexed at 10° of dorsiflexion.[17] All torques were detected by strain gauges, amplified (Biopac Systems Inc., DA 100: analog-digital converter; Holliston, MA) and monitored on a computer (Sona Phoenix, St. John's, Newfoundland). Data were stored on a computer at a sampling rate of 2000 Hz. Data were recorded and analyzed with a commercially designed software program (AcqKnowledge III, Biopac Systems Inc., Holliston, MA).

Taping Method

The same certified athletic therapist applied the tape bilaterally to each subject. Cramer® Tuf-Skin tape adherent (Gardner, Kansas) was initially sprayed on the feet of each participant. Next, Cramer® heel and lace pads (Gardner, Kansas) were applied to both feet at the posterior calcaneus and dorsum of the foot at the ankle (talocrural joint) to help prevent blistering from friction associated with the tape application. Cramer® Skin Lube lubricating ointment (Gardner, Kansas) had been placed on the heel and lace pads prior to application. The tape, 1½ inch zinc oxide Johnson and Johnson Coach® athletic tape (Princeton, New Jersey), was then applied bilaterally to the participants in either the heel-lock or figure-eight methods, as according to Perrin.[18]

The Gibney closed basketweave with HL taping procedure had the ankle positioned at 90º of dorsiflexion. Two anchor strips were placed on the distal leg (foot anchors were left out as they frequently cause constriction and discomfort).[18] A stirrup was applied from the medial aspect of the leg and pulled under the heel to the lateral aspect of the leg using the malleoli as landmarks. A horizontal horseshoe strip was placed from the medial to lateral aspect of foot, while another stirrup was placed in a weaving fashion. The horseshoe and then the stirrup process were continued until three stirrups were applied. The leg was enclosed with horizontal strips ensuring no skin was visible. Heel-locks were applied in a single manner (pulling in upward direction).

The other taping condition included the Gibney closed basketweave with heel-lock as well as a figure-eight. The additional figure-eight taping started on the lateral malleolus and continued down and under the medial aspect of the foot pulling up over the dorsum of the foot to the medial malleolus and around the back of the Achilles tendon and returning to the lateral malleolus. This process was repeated twice for the Figure 8 option.

Testing

Testing was conducted before and after exercise under three conditions: control, heel-locks and figure-eights. The treatment order was randomly assigned. Each testing condition occurred on separate days. Separate testing conditions were conducted within a range of 24–72 hours. Measurements included ankle joint active ROM, plantarflexor maximal voluntary control, and vertical jump tests involving concentric only squat jump (COSJ), countermovement jump (CMJ), and drop jumps (DJ). Ankle active ROM was always tested initially since dynamic jumping movements could loosen the tape adhesion. All jump measures were completed in a randomized order to prevent any effects from fatigue or learning.

Measurements of active ROM at the ankle joint were taken between full dorsiflexion and full plantarflexion for both feet *(Figures 1 and 2)*. The focus of the paper was on the effects of these two adhesive ankle-taping methods on performance (strength, power, and ROM). Thus, changes in the plantarflexor and dorsiflexor ROM could possibly affect jump performance by hindering impulse (force x time) and work (force x distance) performed. Dorsiflexion *(Figure 1)* and plantarflexion *(Figure 2)* active ROM were measured as the participant sat with their leg hanging from a bench. Participants then contracted either their dorsiflexors or plantarflexors maximally in order to achieve the greatest active ROM possible. A goniometer was used with one lever of the goniometer placed on the proximal fibular head, while the other was placed on the fifth metatarsal. The pivot was positioned on the lateral malleolus. The ROM was recorded based on the position of the lever on the fifth metatarsal. The same certified athletic therapist completed all active ROM measurements.

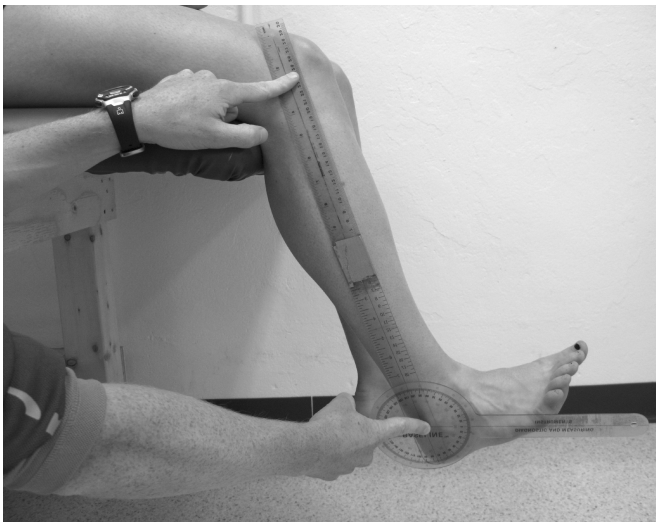

Figure 1: *Illustration of positioning of the goniometer for measurement of active dorsiflexion range of motion.*

For the maximal voluntary contraction, participants placed their dominant leg in the modified boot apparatus, with their ankle at 10º of dorsiflexion, which is the optimal angle for plantar flexion force production.[16] Participants were instructed to plantarflex their foot as fast and as hard as possible. The contraction was held for three seconds at which point they were given a three-minute rest before the second trial began. If a third trial was necessary (greater than 5% difference in force between

first two trials) another three-minute rest was allocated.

The CMJ is similar to sport specific situations, therefore, emphasizing game-like maneuvers. Participants stood with their feet shoulder width apart and flat on the contact mat. With hands on hips, they were instructed to jump as high as possible by using their own choice of depth and pace. Allowing the subject a choice ensured that participants were using a comfortable jumping technique that they would normally utilize in an athletic setting. An athletic population was utilized due to their familiarity with the jumping technique, thereby, reducing variability.

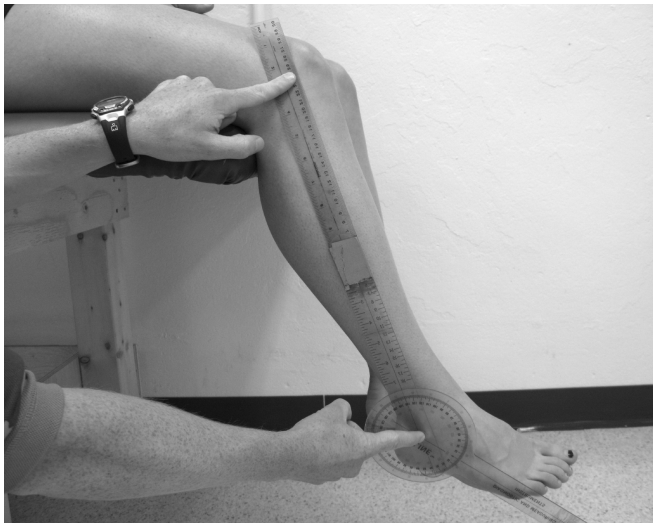

Figure 2: *Illustration of positioning of the goniometer for the neutral ankle position for active range of motion measurements.*

The DJ, which emphasized the stretch-shortening cycle of the ankle, was performed with the participants standing with both feet flat on a 30cm high platform. This height has been used in previously published studies[16,19,20] to ensure an optimal combination of jump height and minimum contact time. With hands on hips, participants were instructed to drop off the platform by stepping forward with whichever foot felt most comfortable. This foot was then used to initiate the DJ for all further testing. Upon contacting the mat with both feet, they were told to jump as high and as fast as possible. Subjects attempted to limit excessive knee flexion such that the ankle was emphasized to a greater extent in the generation of the jump forces.

The COSJ was tested due to its emphasis on impulse generation.[16] With hands on hips, participants stood with feet shoulder width apart and flat on the contact mat with their knees flexed at 90º. This position was held for two seconds. After the two-second period they were told to jump as high as possible.

A thirty-second recovery was provided between all jump trials. Jump height was used as the indicator of best performance for all jumps. The three jumps were chosen to ascertain the effect of taping on three physiological parameters. This particular form of DJ was performed with specific instructions to mainly involve a rapid stretch-shortening cycle action of the ankles.[16,19,20] In contrast, the CMJ used a moderate speed stretch-shortening cycle (angular speed dependent on participant's preference) which emphasized both knees and ankles which contrasted with the COSJ that lacked a significant stretch-shortening cycle.

Previous research from our laboratory[22] has reported the following intraclass correlation coefficients (ICC) for plantarflexor range of motion (0.94), squat jump (0.96), countermovement jump (0.93) and drop jump (0.89) respectively. Other research from our laboratory utilizing the plantarflexor maximal voluntary control has shown ICC values ranging from 0.91 – 0.99.[17]

Participants then completed a ten-minute exercise protocol on a treadmill (9.6 km.h-1) at a level grade followed by a three minute cool down (4.5 km/hr) to initiate the loss of the tape's restrictive properties. The treadmill speed was chosen to provide a typical pace used in a pre-competition warm-up by these athletes. This speed was based on pilot studies utilizing the same athletes. At completion of the exercise protocol the testing procedures were repeated in a randomized order with active ROM again being completed first. Only two trials of each testing procedure were necessary unless there was more than a five percent difference between the two measurements and then a third measurement was conducted. All measurements were recorded with the best performance (maximal voluntary control force and jump heights) used for the data analysis

Data Analysis

The data was analyzed using a two way ANOVA (two times: pre- and post-exercise x 3 tape conditions: control, heel-locks, figure-eights) with repeated measures. An alpha level of $p < 0.05$ was considered statistically significant. If significant differences were found, a Bonferroni-Dunn's procedure was conducted to identify where the significant change occurred. Effect sizes (ES = mean change / standard deviation of the sample scores) were

also calculated and reported.[21] Cohen[21] applied qualitative descriptors for the effect sizes with ratios of <0.40, 0.41-0.70 and >0.7 indicating small, moderate and large changes, respectively. Means and standard deviations (SD) are reported in the text and figures.

RESULTS

Overall, for all dependent variables tested (maximal voluntary contraction force, CMJ, DJ, COSJ), except the active ROM, no significant differences existed for the taping method or the effect of exercise when comparing any of the independent variables (control, heel-locks, figure-eights)*(Table)*. The control condition exhibited 24.9% and 27.5% significantly ($p < 0.05$) greater plantarflexion active ROM as compared to HL (ES = 0.99) and F8 (ES = 1.11) tape methods respectively *(Figure 3)*. In addition, 25.7% and 9.6% significantly greater plantarflexion ($p < 0.05$; ES = 0.85) and dorsiflexion ($p < 0.05$; ES = 0.5) active ROM for both ankles were detected following exercise independent of the taping method *(Figure 4)*.

DISCUSSION

The results of our study indicate that a significant reduction in plantarflexion active ROM occurred as a result of the two different tape application methods (heel-lock and figure-eight) as compared to the control. This is in agreement with other studies that reported similar conclusions as a result of the utilization of external ankle supports.[2,4,9]

It had been theorized that tape restriction would impede the force generated by the plantarflexors. However, the present study indicated that maximum force production was not reduced as a result of tape application as no significant maximal voluntary control differences existed between the type of taping method (heel-locks or figure-eights) and the control, pre-, or post-exercise groups.

Table: *Pre- and post-exercise means and standard deviations for all variables. The following definitions are defined as df = degrees of freedom, F = F ratio and p = probability value, MVC = maximal voluntary control.*

	Heel lock Pre-exercise	Heel lock post-exercise	Figure 8 pre-exercise	Figure 8 post-exercise	Statistics
Countermovement jump (cm)	24.9 ± 3.6	24.7± 5.6	23.6 ± 3.2	25.3 ± 2.8	df = 32 F = 0.04 p = 0.43
Drop jump (cm)	20.7 ± 4.3	21.4 ± 4.7	21.2 ± 4.4	22.1 ± 4.6	df = 32 F = 0.05 p = 0.94
Drop jump contact time (ms)	232.9 ± 38.7	230.1 ± 31.1	216.6 ± 46.1	241.2 ± 30.1	df = 32 F = 0.07 p = 0.48
Concentric only squat jump (cm)	24.2 ± 3.4	23.5 ± 2.2	23.7 ± 3.4	24.7 ± 4.1	df = 32 F = 1.44 p = 0.25
Plantarflexors MVC (Newtons)	251.7 ± 55.6	253.6 ± 51.8	232.9 ± 51.1	217.3 ± 69.5	df = 17 F = 0.35 p = 0.71
Dorsiflexion ROM (degrees)	10.4 ± 1.0	11.1 ± 1.8	10.1 ± 0.6	11.5 ± 0.7	df = 32 F = 8.19 p =0.007
Plantarflexion ROM (degrees)	27.9 ± 10.8	35.5 ± 11.8	26.0 ± 8.5	35.3 ± 11.6	df = 32 F = 37.8 p<0.0001

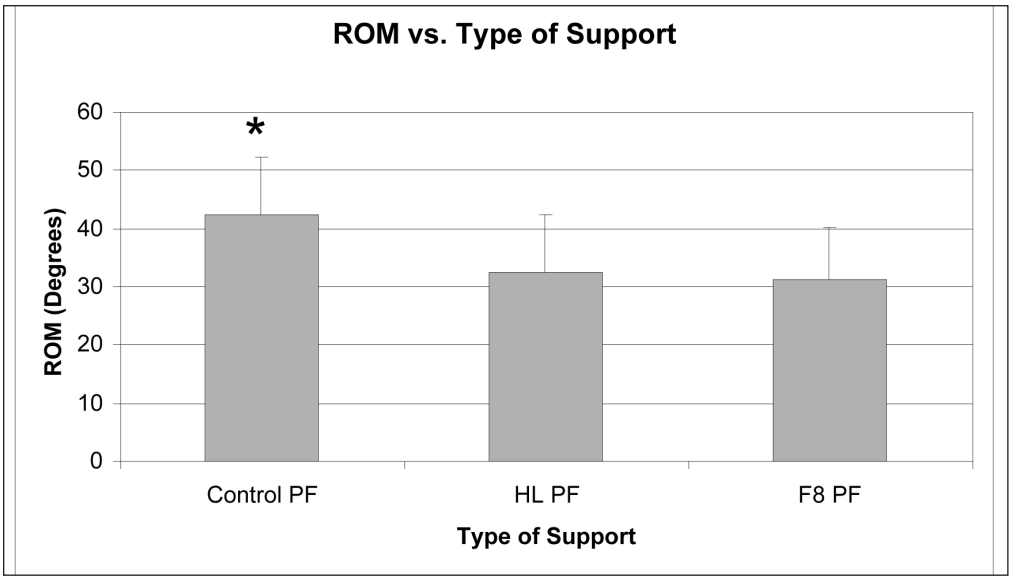

Figure 3. *The asterisk (*) indicates a significant ($p < 0.05$) difference in plantarflexors (PF) ROM between the control (NS: no support) and type of taping (HL: heel lock, F8: heel lock, and figure 8) method. The acronyms PF, DF, HL and F8 refer to plantarflexors, dorsiflexors, Gibney closed basket weave with heel lock, and Gibney closed basket weave with heel lock and figure 8, respectively.*

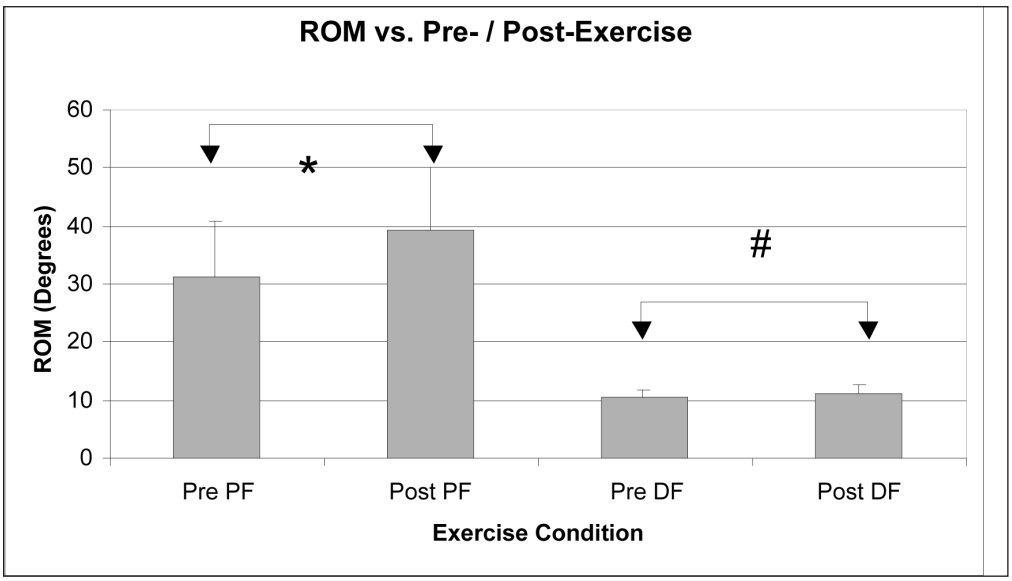

Figure 4. *The asterisk (*) indicates a significant difference ($p < 0.05$) between plantarflexors (PF) ROM pre- and post-exercise. The number sign (#) indicates a significant difference ($p = 0.05$) between dorsiflexors (DF) ROM pre- and post-exercise. The acronyms PF and DF refer to plantarflexors and dorsiflexors, respectively.*

These results concur with previous research that has tested maximum force production when ankles have been taped.[2,4,7]

Cordova et al[4] reviewed the literature indicating that taping did not decrease the magnitude of the forces produced, but the rate at which they were produced was slower. Alternatively, the present research did not find a significant difference in DJ contact time with taping. Muscle force and power have been reported to be compromised with increased muscle compliance.[22,23] The elongation of tendinous tissues can also have a deleterious effect on force output.[24] Belli and Bosco[25] suggested that a stiffer musculotendinous unit would enhance the work performed during stretch-shortening cycle movements. Perhaps the restricted ROM of the taping methods contributed to a stiffer or less compliant ankle joint which permitted a more rapid stretch-shortening cycle during the DJ contact time. Hence, although the tape restricted ankle ROM, the tape did not decrease the maximal voluntary contraction force generated by the ankle-foot complex during the DJ.

Plantarflexion is required for propulsion[5,6] and during the push off phase[11] of a vertical jump. The results of the present study indicate that no significant reductions in vertical jump height occurred with any condition tested. Similar research also reports a lack of change in vertical jump height with the application of external ankle supports.[7,10,11,15] Verbrugge[7] utilized the heel-lock method while Paris[10] utilized the figure-eight method. Neither study recorded a significant reduction in vertical jump

height under these conditions. Other studies however have recorded significant reductions in vertical jump heights as a result of external ankle supports.[1,8] Possible reasons for the lack of vertical jump impairment would include the aforementioned insignificant effects of ankle taping on maximal voluntary contraction force and the possible positive effect of increased ankle joint stiffness on the stretch-shortening cycle. Furthermore, ankle taping has also been found to increase proprioception and sensorimotor function through the stimulation of cutaneous mechanoreceptors.[3,4,13] It has been theorized that the activity of these mechanoreceptors are enhanced as a result of the pressure an external ankle support places on the lower leg.[13] If prime movers such as the plantarflexors are stimulated, these muscles could counteract the effect of the restricted plantarflexor ROM.

A study by Kean et al[26] implementing six weeks of wobble board training, found an increase in vertical jump height. This study demonstrated that an improvement in stability could positively affect vertical jump height, as enhanced stability helps to direct jump forces in a vertical direction as opposed to slight deviations from vertical. In addition, improved stability can allow for a greater amount of force to be produced.[17,27] The muscles involved in the movement can be dedicated more to producing motion rather than joint stabilization.[26,27] As ankle taping improves stability, both of these factors have the potential of counteracting some of the negative effects from a reduction in ankle ROM.

The results of this study also indicated that significant increases occurred in plantarflexion active ROM across all conditions pre- and post-exercise. This finding is in agreement with other studies that attributed the increased ROM to the loosening of the tape as a result of exercise.[7,15,28] Researchers have reported 40-50% of the tape's initial restrictive support is lost following just 10 minutes of activity.[7] Despite the loosening of the tape and the increase in ROM, the tape still provides adequate restriction of ROM to aid in injury prevention.[28] The proprioceptive stimulation provided by the adhesive tape to the lower leg would also be an aid for injury prevention.

Limitations of the present study include the small sample size (n = 11) and the convenience sample. As the sample included only female varsity athletes, the application of the present findings to other populations may be somewhat limited. Further research should examine the effect of other taping methods on performance, inversion/eversion range of motion and more varied samples (males, recreationally active individuals, younger and older individuals, individuals with present or former ankle sprains). More sophisticated analysis could be accomplished if similar research was conducted on a reaction force platform which could monitor changes in three planes, as well as proprioceptive testing.

CONCLUSION

Despite ankle active ROM being restricted by both taping procedures (heel-locks and figure-eights), no effect on vertical jump performance, contact time, or maximal voluntary contraction force occurred. As a result, the personal preference of the clinician, athlete, or coach can be used to determine the taping method without the possibility of decreasing vertical jump height.

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